C N S /A T M for N a v a l A v i a t i o n

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V o l u m e 2 , I s s u e 1 , J a n u a r y 3 , 2 0 0 0

Purpose

This newsletter provides information to the Naval aviation community concerning requirements, issues, and developments in Communications, Navigation and Surveillance / Air Traffic Management (CNS/ATM).

CNS/ATM NEWS

CAA ADS–B Demonstration

Based at the Naval Air Station, Patuxent River, MD, a Navy P-3C, modified by NAWC-AD, participated in Ohio Valley tests on 10 July, 1999 to demonstrate three Automatic Dependent Surveillance-Broadcast (ADS-B) technologies. Sponsored by the Cargo Airlines Association (CAA) and the FAA, this demonstration investigated three competing ADS-B data link technologies: Mode S, Universal Access Transceiver (UAT), and VHF Data Link - Mode 4 (VDL-4).

Our purpose in participating was to gather human factors and system performance data for evaluating ADS-B use by the Navy. Basing the implementation upon the CAA sponsored ADS-B system, the intent was to integrate ADS-B equipment with minimum impact on existing P-3 aircraft avionics. To that end, a Naval Avionics Platform Integration Emulator (NAPIE) was used. NAPIE allows rapid decoupling of equipment under test. Besides platform interface avionics, NAPIE included transceivers for Mode S, UAT, and VDL-4. A Cockpit Display of Traffic Information (CDTI) was mounted just to the right of the pilot's seat. The CDTI, being an engineering model, did not meet the latest flight quality visual standards. Seven antennas were mounted to support the three data links, as nearly as possible to the optimum performance locations.

Data gathering consisted of recording various system and display inputs, and videotaping the CDTI during the test. Data was generally assessed along four main themes:

- Situational awareness enhancement,
- Impact on pilot workload,
- Accuracy of CDTI own ship and target display, and
- Overall ADS-B accuracy.

Weeks prior to the flight, the crew had a 2-hour ADS-B familiarization in a 757-based simulator after reading the pilot's guide. Using a FAA Convair 560 as a cooperative target, the P-3 flew various test profiles (trail, overtake and climb, etc.) during the approximately 2 1/2 hour flight. Both aircraft recorded various flight parameters for later comparison and analysis.

During the flight, due to location, both the co-pilot and flight engineer had difficulty observing the CDTI. Also, the CDTI control panel push buttons were too small for gloved hands. The VDL-4 data link failed to operate on both the P-3 and the FAA Convair, and, therefore, the ground stations did not record VDL-4 data. However, both the Mode S and UAT were operational throughout the test, each with detection ranges greater than 175 nm.

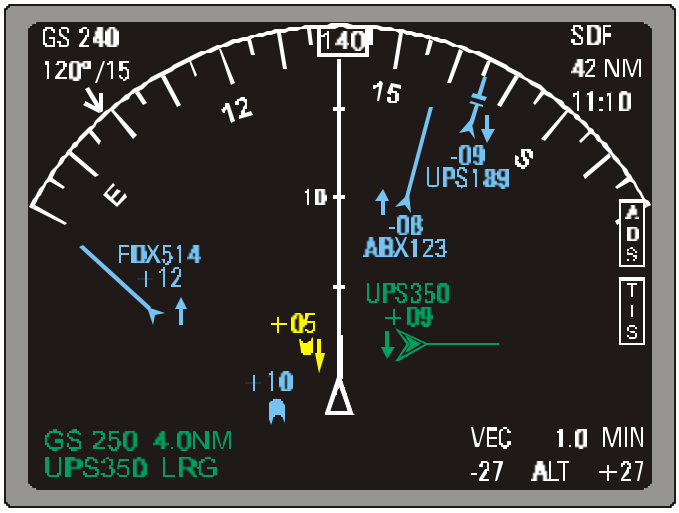
Overall, the pilots felt that CDTI enhanced situational awareness except on the ground where there was too much display clutter. Display accuracy of own ship versus target gave pilots confidence in executing maneuvers around the Convair. The display was intuitive, and generally easy to operate. However, in a few instances such as setting altitude limits, instructions on the menu were cumbersome, or incorrect, in the case of setting the flight identification. The built-in-test display was too simplistic, lacking details.

After-flight data analysis noted that CDTI latitude and longitude readings were accurate, that pressure altitude readings were accurate during level flight with a 20 foot difference in ascent / descent, and that heading readings were accurate during level flight with differences of several degrees noted during turns. Display refresh rates were sufficient so that heading, compass rose, and selected targets moved smoothly except when a range of one nm was selected. Target jitter was evident during range – one-nm selections. As expected, the CDTI displayed targets using proper symbology and color.

Provided from ground stations, Traffic Information Services (TIS) data was intermittent, inconsistent, and inaccurate. TIS targets appeared randomly, created ghost images of ADS-B targets (generating false traffic alerts), and often obscured ADS-B target information.

For comprehension, the figure below from the pilot's guide is included. Own ship data is white, selected ADS-B target is

green, proximate targets are cyan, and traffic alerts are in yellow. Own ship symbology is a triangle, other ADS-B aircraft data are chevrons, TIS aircraft are bullet shaped, and ascending and descending aircraft are indicated by appropriate arrows.



Ground track vectors (GTVs) (the line extending from the chevron proportional to the selected time interval in lower right hand corner) were useful in rendezvous, but could not be disabled from the control panel. A GTV that would extend past the selected range is indicated by the broken line above in the upper right quadrant. GTVs have little utility on the ground.

A range ring (not shown above) (a dashed line display of approximately 50% of the selected range) was useful for station keeping giving an intuitive graphic of the relationship to the target. The number indicating the range ring scale, however, was overwritten by the ring.

A ground closure indicator (GCI) (a thick bar emanating from the target (not shown above) or own ship (see above)) to be displayed when the closing or opening rate exceeded 5 knots was inconsistent in terms of speed differences, especially when in trail. It also lagged changes in ground speed.

Targets selected from the control panel were maintained by the CDTI when outside the selected range display limits up to 80 nm. Targets were automatically dropped over 80 nm.

There were two instances where the CDTI froze when the target exceeded the selected altitude limits (indicated above in the lower right corner). One period lasted 30 seconds. The pilot accessed the menu while the target was pulling away. Coming back to the display, the CDTI displayed the Convair behind the P-3 and drifting. The second instance was 8 seconds. Target information (lower left-hand corner) disappeared, but the target chevron remained with an obviously inaccurate relative altitude.

Impact on the pilot's workload was mixed. Obviously, there was more head-down time viewing the CDTI. The availability of information on the display potentially could allow pilots to make Air Traffic Control (ATC) decisions or confuse other pilots or the ATC by using call signs. Additionally, pilots may forget that not all aircraft are displayed – a safety hazard.

In cooperation with the CAA, the FAA recorded data from most of the 12 CAA aircraft participating in the day's flights. Performing the human factor's analysis for the FAA, NASA – Ames Research Center's preliminary findings mirror our Navy analysis. Setting up the CDTI functions was easy, according to the civil pilots. The CDTI was an aid in visual acquisition of targets and an aid in increasing awareness of multiple targets. Display clutter was a problem, especially when on the ground. Head down time increased when using the CDTI. One finding not investigated by the Navy was that the CDTI was an aid in determining when traffic touched down. The color used for ground targets (tan) did not contrast well with the CDTI background color. Like our analysis, NASA-Ames also determined that the CDTI was useful in station keeping. They also found the same issues with TIS.

Both Navy and civilian pilot and crewmembers noted that the CDTI display was stand-alone. They recommend that a fully integrated system be researched. In addition, civilian crewmembers also experienced viewing angle deficiencies.

An area analyzed by NASA-Ames that the Navy did not analyze was the reactions of ATCs. Since the controllers used their existing procedures and since the number of aircraft involved was relatively small compared to a normal workload, the difficulty from their perspective was average. Controllers, for the most part, rated ADS-B as a high contributor to safe and efficient traffic flow. They noted improved situational awareness since pilots could anticipate traffic to follow. Controllers felt that ADS-B would especially be advantageous at night. While controllers remained concerned over the use of other aircraft call signs, they were useful in rapidly resolving a following-wrong-traffic situation.

A briefing of the CAA ADS-B demonstration results including selected videotape examples, and a briefing of CNS/ATM program status as well as other selected equipment will be part of the agenda of the PMA 209 Users Conference to held in San Diego, the week of 7 February 2000. For more information, visit the conference website at www.genscicorp.com/pma209/.